複数動作の組み合わせによる操作インタフェースに関する研究

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A Study on Operation Interfaces Using Combined Motions

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Abstract

Recently, people have more and more opportunities for contact with information terminals in daily life, which are set in various public or private places or carried by them. The number and kinds of commands to these information terminals are increasing since the terminals, which can access the Internet and other terminals in the local area network, offer rich functions to reach rich content or give them rich service.

In this thesis, we define operation interfaces as relationship between the set of commands to an information terminal and users' motions to specify the commands to the terminal. Users demand an operation interface, which allows them to give commands effectively to an information terminal with less physical and mental burden. Meanwhile, low-cost sensors with high accuracy and small sizes appear recently and operation interfaces using various motions observed by the sensors are being investigated. In the future, it is expected that operation interfaces using combined motions will be increasing. Against this background, it is important to repeat not only trial and error of operation interfaces but also to establish design guidelines due to complicated design of operation interfaces between the large number of commands and various motions observed by various sensors.

In the first chapter, operation interfaces are categorized into three groups, namely, direct operation interfaces using an individual motion (e.g. channel selection on TV using remote controller), sequential operation interfaces using an individual motion (e.g. multi-touch operation interface to input text using a mobile phone) and operation interfaces using combined motions, and we propose a model of each operation interface group to analyze the characteristics of an operation interface.

First, we describe a model expressing direct operation interfaces using individual motion. We define an individual motion as a class of motions to give commands to an information terminal such as pressing keys on a remote controller and define direct operation interfaces as relationship in which each command to the terminal corresponds with each canonical motion in the class of motions. The model consists of a motion space, a motion feature space and a command set. We define a motion space as a state space whose element is a state variable determined by the motion by the current time. The state variables include enough information to specify a command to the terminal. We define a motion feature space as a space whose element is a feature variable mapped from a state variable in a motion space. The feature variables are typically values observed by sensors or quantities generated from those values. The feature variables are then used as input for a processing algorithm to decide the command implemented in the terminal. We define a set of command as a set which has an element mapped from a feature variable in a motion feature space. A command is executed when a motion is completed.

The mapping from feature variables to a command is not always injective and state variables mapping to a feature variable is not always injective. However, it is considered that users are aware of not all feature variables and all state variables but a representative set feature variables and state variables corresponding to a command as a canon. We call representative feature variable a canonical feature variable. We call representative state variables a canonical motion. Since canonical motions are guides for a user to learn the motions corresponding to the commands, it is preferable that the canonical motions are easy-to-learn motions for a user.

The inverse image of a command should include not only a canonical feature variable corresponding to the command but also feature variables in a neighborhood of the canonical feature variable, by which it is possible to care about measurement errors of sensors and imperfect classification algorithms mapping feature variables to a command. The inverse image of a command must not overlap that of another command to decide a command corresponding to a motion uniquely. Therefore, it is preferable that a margin between canonical feature variables is large enough to give a command to an information terminal correctly. The inverse mapping of feature variables corresponding to a command in a motion feature space includes a canonical motion corresponding to the command and state variables in a neighborhood of the canonical motion. Since a user cannot always repeat a canonical motion correctly, it is preferable that the neighborhood is large enough in a motion space. However, a large margin between canonical motions gives users a great burden of an operation to input multiple commands successively to an information terminal. Also, a measuring range of sensors and a motion range of a human body limit the possible range of the motion feature space. The larger a margin between canonical feature variables is, the smaller the number of canonical feature variables in the motion feature space range is. We call this limited number of canonical features the resolution of the motion feature space.

Thus, the proposed model of direct operation interface using an individual motion suggests that we have to focus on the following points, namely, a timing when a motion corresponding to a command is completed, feature variables generated from measurement data of sensors, motion accuracy of users, accuracy of measurement of sensors and a processing algorithm, and feature resolution. We call a command corresponding to a motion in direct operation interface using an individual motion a basic command.

Next, we describe a model expressing sequential operation interfaces using individual motion. A motion used in a sequential operation interface using an individual motion is a repetition of motions used in a direct operation interface. The characteristics of motions in the sequential operation interface inherit ones in the direct operation interface. A command is expressed by a timeline of basic commands. The larger the number of motion repeatition is, the longer a time to finish a motion corresponding to a command is and the larger a burden of a sequential motions is. The number of motion repetition should be limited in each direct operation interface in an individual motion.

Then, we describe a model expressing operation interface using combined motions. Combines motion is to a combination of motions in direct/sequential operation interface with a motion in another direct/sequential operation interface. A motion in an operation interface using combined motions inherits the characteristics of an individual motion in each direct/sequential operation interface. In addition, usability of an operation interface using combined motions depends on a compatibility of each motion in each direct/sequential operation interface.

In the second chapter, we focus on a task in which a user gives a TV a command to express a character corresponding to the command on the display using a remote controller with physical keys far from the TV. We aim to realize an operation interface which allows a user to input a Kana-character effectively without looking at a remote controller. Since the number of commands to input Kana characters is over 50, a sequential operation interface using an individual motion or an operation interface using combined motions is required. We investigate resolutions of direct operation interfaces using an individual motion observed by sensors through analysis of related work and experiments. We propose “Twist&Tap” as an operation interface using combined motions selected from among combinations of direct/sequential operation interfaces using an individual motion as aspect of usability and compatibility of combined motions. Twist&Tap is an operation interface using the combined motions which consist of thumb motion to press four direction keys and five level twist motion of the wrist to tilt a remote controller.

The contributions of this chapter are to show that resolutions of an operation interface using a twist motion without looking at the motion through an experiment, that subjects can input characters using Twist&Tap without looking at a remote controller while they cannot easily input characters using Multi-tap operation interface without looking at a remote controller through an experiment. In conclusion of this chapter, we explain that studying resolution of direct operation interface using individual motion and studying compatibility of a combination of individual motions are useful to analyze features of motion used in designed operation interface using combined motions.

In the third chapter, we focus on a task in which a user gives a large display a command to select an item on a menu with over 30 items using gestures. We aim to realize an operation interface which allow a user to select a item by one action of simple gestures which a user can acquire easily and the terminal recognize with high accuracy. We propose “Unicursal Gesture Interface” or UGI in short. UGI is an operation interface using the combined motions which consist of a motion to draw unicursal figures and a motion to decide a position of start and end points of a unicursal figure. Most of gesture interfaces proposed in related work are direct operation interface in an individual motion and the numbers of gestures are limited to as few as 30. Meanwhile, UGI, which is operation interface using conbined motions, only needs the resolution of direct operation interface using motions to draw unicursal figures is over 8 and a resolution of direct operation interface using a motion to decide is 4 directions of a start and end point.

The contributions of this chapter are to show that the proposed algorithm to detect start and end point of a drawn unicursal figure is effective through an experiment and that recognition rate of 8 unicursal gestures with bottom start and end point was average 94.7% through an experiment. In conclusion of this chapter, we explain that it is useful to resolve an direct operation interface using an individual motion and reconstruct the resolved direct operation interfaces as an operation interface using combined motion.

In the forth chapter, we focus on a task in which a user gives an information terminal with a touch screen commands to explore 3D information space on 2D tablet. We aim to realize an operation interface using intuitive motions. We propose “Kuru-Miru” as an operation interface using combined motions which consist of a motion to move a ring object with conductive points and a motion to rotate a ring object with conductive points with looking at information inside the ring object. Since users move and rotate the ring simultaneously, they control the object effectively. The usability of this operation interface depends on accuracy of detecting a position of a conductive point.

The Contributions of this chapter are to show that a conductive point with 2mm × 2mm size is required for a touch screen to detect a position of the point through an experiment and that usability of the proposed method is high through an experiment. In conclusion of this chapter, we explain that a resolution of an direct operation interface using an individual motion depend on accuracy of motions and sensors.

In conclusion, we describe that the proposed model of an operation interface is useful to analyze features of an operation interface. In the future, we confirm a validity of the proposed model by analyzing various operation interfaces and create a new operation interface.